COPY FOR MR. J. ALLAN ROSS

HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

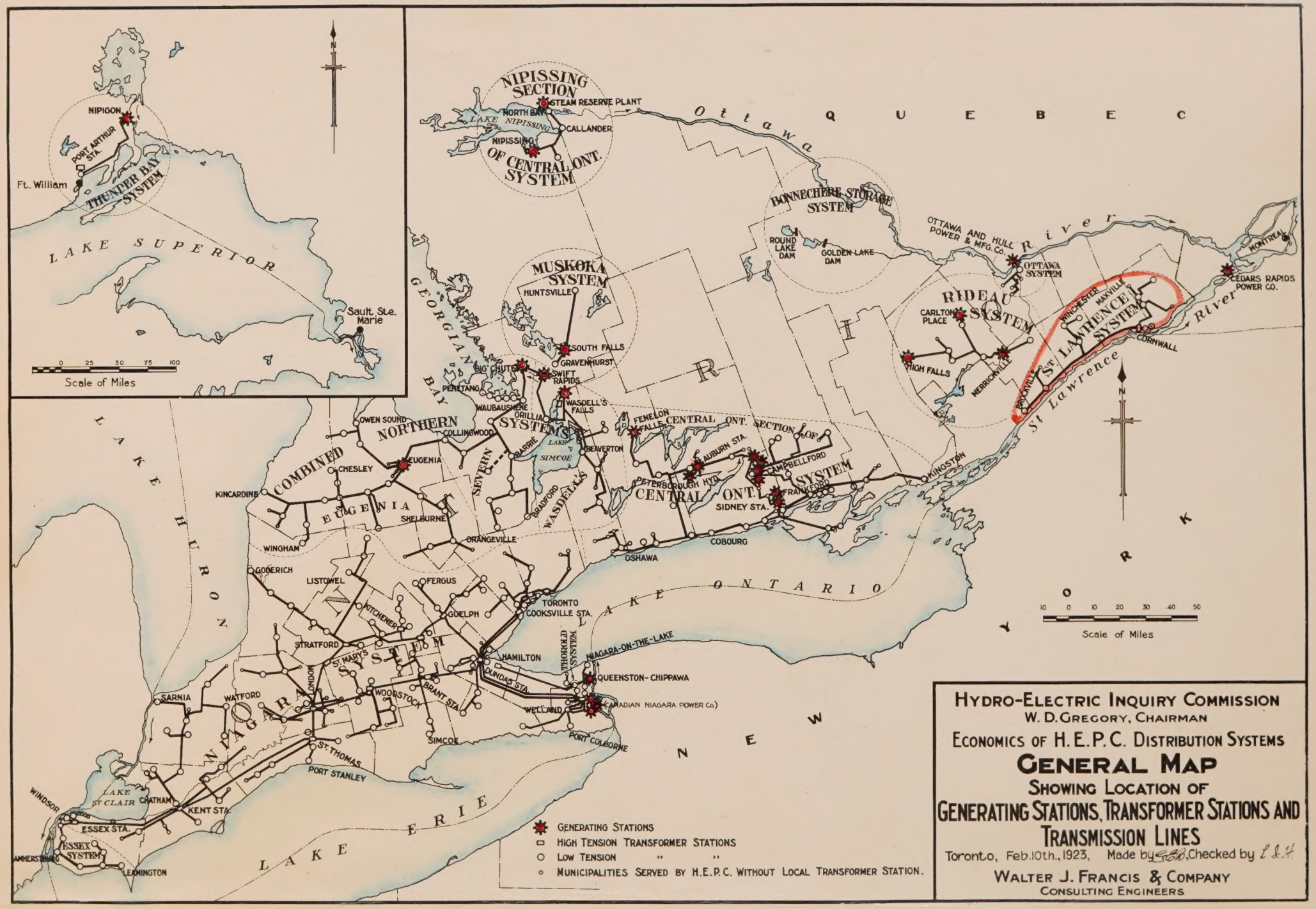
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

STUDY OF ST. LAWRENCE SYSTEM

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS

ST. LAWRENCE SYSTEM


HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H.E.P.C. DISTRIBUTION SYSTEMS
GENERAL MAP
SHOWING LOCATION OF
GENERATING STATIONS, TRANSFORMER STATIONS AND TRANSMISSION LINES
Toronto, Feb. 10th., 1923, Made by G.E.B., Checked by L.S.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS
GENERATING STATIONS
HIGH TENSION TRANSFORMER STATIONS
LOW TENSION " "
MUNICIPALITIES SERVED BY H.E.P.C. WITHOUT LOCAL TRANSFORMER STATION.
Scale of Miles
0 25 50 75 100
10 0 10 20 30 40 50
LAKE SUPERIOR
LAKE HURON
LAKE ONTARIO
LAKE ERIE
LAKE ST CLAIR
GEORGIAN BAY
Ottawa River
St Lawrence River
QUEBEC
NEW YORK
NIPIGON
PORT ARTHUR STA.
Ft. William
THUNDER BAY SYSTEM
Sault Ste. Marie
NIPISSING SECTION OF CENTRAL ONT. SYSTEM
STEAM RESERVE PLANT
NORTH BAY
CALLANDER
NIPISSING
BONNECHERE STORAGE SYSTEM
ROUND LAKE DAM
GOLDEN LAKE DAM
OTTAWA AND HULL POWER & MFG. CO.
OTTAWA SYSTEM
MONTREAL
CEDARS RAPIDS POWER CO.
MUSKOKA SYSTEM
HUNTSVILLE
SOUTH FALLS
GRAVENHURST
BIG CHUTE
SWIFT RAPIDS
PENETANG
WAUBAUSHENE
WASDELL'S FALLS
ORILLIA
RIDEAU SYSTEM
CARLTON PLACE
HIGH FALLS
MERRICKVILLE
ST LAWRENCE SYSTEM
WINCHESTER
MAXVILLE
BRIGHTON
CORNWALL
OWEN SOUND
NORTHERN SYSTEM
COLLINGWOOD
BARRIE
LAKE SIMCOE
BEAVERTON
FENELON FALLS
CENTRAL ONT. SECTION OF
AUBURN STA.
CAMPBELLFORD
FRANKFORD
SIDNEY STA.
PETERBOROUGH HYD.
CENTRAL ONT. SYSTEM
KINGSTON
COMBINED EUGENIA
CHESLEY
EUGENIA
KINCARDINE
SHELBURNE
SEVERN
BRADFORD
WASDELL'S
ORANGEVILLE
WINGHAM
GODERICH
LISTOWEL
FERGUS
OSHAWA
COBOURG
TORONTO
COOKSVILLE STA.
KITCHENER
GUELPH
STRATFORD
ST. MARYS
LONDON
HAMILTON
THOROLD SYSTEM
NIAGARA-ON-THE-LAKE
QUEENSTON-CHIPPAWA
(CANADIAN NIAGARA POWER Co.)
DUNDAS STA.
WELLAND
PORT COLBORNE
NIAGARA SYSTEM
SARNIA
WATFORD
WOODSTOCK
BRANT STA.
SIMCOE
ST. THOMAS
PORT STANLEY
WINDSOR
CHATHAM
KENT STA.
ESSEX STA.
ESSEX SYSTEM
AMHERSTBURG
LEAMINGTON

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

To face frontispiece.

General Map Showing Location of

Generating Stations, Transformer Stations and Transmission Lines

of the

Hydro-Electric Power Commission of Ontario.

COPY

The area outlined in red shows the

St. Lawrence System.

INDEX TO ST. LAWRENCE SYSTEM

INDEX TO ST. LAWRENCE SYSTEM

LIST OF ILLUSTRATIONS

ST. LAWRENCE SYSTEM

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Toronto, Ontario,

February 19th, 1923.

Hydro-Electric Inquiry Commission,
W. D. Gregory, Esq., Chairman,
T O R O N T O, Ontario.

re Studies of Engineering Economics of the
St. Lawrence System of the
Hydro-Electric Power Commission of Ontario.

Mr. Chairman and Gentlemen,-

In accordance with the letter to your Commission under date of November 4th, 1922, and your confirmation of the general instructions under date of November 15th, 1922, a study has been made of the engineering economics of the St. Lawrence System of electrical distribution operated by the Hydro-Electric Power Commission of Ontario. The work has been done under the direct personal supervision of Mr. Frederick B. Brown, M. Sc., M.E.I.C., a partner in the firm of Walter J. Francis & Company, in accordance with your instructions.

The subject has been discussed with Mr. Commissioner R. A. Ross in detail, and, generally, with Mr. Bower, the Secretary of your Commission, and constant communication has been maintained with the officials of the Hydro-Electric Power Commission of Ontario.

The reports of Messrs. Price, Waterhouse & Co. have been used as the basis of the financial figures given herein, and reference has been made to the records of the Hydro-Electric Power Commission of Ontario where it was necessary to do so to prepare the diagrams.

It is understood that it is not within the scope of the instructions to examine into any of the legal aspects of the System nor discuss any of the Acts of the Legislature relating to it.

The necessary technical data has required considerable preparation, as much of it is only available in the operating records of the Hydro-Electric Power Commission of Ontario. The printed reports contain a part, but these have had to be supplemented by interviews with various officials, and by searching the voluminous records both at the head office in Toronto and elsewhere.

The general plan under which the report of the studies is presented may be outlined as follows:

(1) A short review of the history and evolution of the System.

(2) A brief physical description of the System.

(3) A brief discussion regarding the characteristics of the local market.

(4) A discussion of progressive capital costs.

(5) Statistics regarding progressive revenues for various classes of service, with discussion thereon.

(6) Statistics regarding progressive operating costs and fixed charges, with discussion thereon.

(7) Statistics showing progressive and accumulated deficits or surpluses, with discussion thereon.

(8) Analysis of progressive operating records and of unit revenues per kilowatt-hour and per horse-power per annum and of unit costs per kilowatt-hour and per horse-power per annum.

(9) A brief discussion of the various important points concerning the System.

The report included herewith as pages 4 to 54 inclusive refers in detail to that portion of the activities of the Hydro-Electric Power Commission known as the St. Lawrence System. References are made to the possible inter-connection of this System with other systems.

Throughout the report diagrams have been included in the order of the text, while the map included as a frontispiece shows the System generally and its geographical relation to all the other systems operated by the Hydro-Electric Power Commission of Ontario.

ST. LAWRENCE SYSTEM

Frederick B. Brown, M. Sc.

Evolution and Development of the System.

The St. Lawrence System as at present constituted is the result of the general development of electrical service on the partnership basis amongst a number of municipalities, commencing about 1910 and extended from time to time. In the course of the development of the System a number of small public and private power plants have been used for a time and discarded, until, at the present time, the sole source of energy is purchased power generated at Cedars Rapids, Quebec.

In December, 1910, a meeting was held in Brockville at which various municipalities from Napanee to Morrisburg were represented. The result of this meeting was to request estimates from the Hydro-Electric Power Commission of Ontario for the supply of power to the district. These estimates were prepared by the Hydro-Electric Power Commission, and it is stated by the engineers that the figures were based on an optional contract for the supply of power from Waddington, New York. Towards the end of 1911 these estimates were supplied to Brockville. About this time Kingston was also negotiating with the Hydro-Electric Power Commission for a power supply from Waddington, New York, but Kingston was eventually supplied from the Central Ontario System. Early in 1912 the municipalities of Prescott and Brockville arranged to take power from the Hydro-Electric Power Commission based on estimates of 300 horse-power for

Prescott at $24.54 per horse-power per annum at 13,200 volts, and for Brockville 1,000 horse-power at $24.04. These two municipalities formed the nucleus of the present St. Lawrence System.

At November 1st, 1913, 45 miles of transmission lines from Morrisburg to Prescott and to Winchester were either in operation or under contract, and a distributing station had been built at Brockville having a capacity of about 450 K.V.A., and transforming from 26,000 volts to 2,300 volts. At this time the proposed contract with Waddington, New York, had not been consummated, but a supply of power had been arranged for from the Rapids Power Company, (New York and Ontario Power Company) at Morrisburg, at 26,400 volts, 3-phase, 60-cycles. During 1913 assistance was given to the Rapids Power Company in connection with their step-up transformer station, Prescott re-modelled its auxiliary steam plant, and the municipalities of Chesterville and Winchester carried by-laws for supply of power, the estimated conditions at Chesterville being 50 horse-power at $35, and for Winchester 100 horse-power at an estimated cost of $24 per horse-power per annum.

During 1914 the three municipalities of Prescott, Winchester and Chesterville were supplied with power, the two former by means of 26,400-volt transmission lines, and Chesterville at 4,000 volts over a seven-mile line from Winchester distributing station.

Brockville commenced receiving power in April 1915 at 26,400 volts, and the village of Williamsburg also received power two or three weeks before Brockville. In the same month the power supply for the System was transferred from the Morrisburg plant of the New York and Ontario Power Company to the hydro-

electric plant of the M. F. Beach Company at Iroquois. The records show that this plant had thereafter a load factor of about 90 per cent.

In 1916 the demands for power on the St. Lawrence System had increased to about 1,000 horse-power which was in excess of the capacity of the generating station at Iroquois. At this time the municipal steam auxiliary station at Brockville was being operated in parallel with the Iroquois generating station, and during the balance of the year 1916, and throughout 1917, power was supplied by the Beach Company at Iroquois and the municipal auxiliary station at Brockville. During 1918 the same operating arrangement was continued and was stated to be satisfactory except that shortage of power was evident. The operation and maintenance of the St. Lawrence System up to this time had been directed from the operating centre of the Central Ontario System at Belleville.

The growth of the load on the St. Lawrence System caused the Hydro-Electric Power Commission to seek other sources of power supply, and on May 1st, 1919, the power supply was changed over to the Cedars Rapids Transmission Company, the power being taken from the Company's 110,000-volt transmission line near Cornwall. It is understood that the arrangement under which the power is taken provides for a maximum supply of 10,000 horse-power to be supplied at 110,000 volts, 3-phase, 60-cycles. The transformer station near Cornwall reduced the voltage from 110,000 to 26,400 volts through three 1,250 K.V.A., single-phase transformers. Arrangements were made in 1919 to supply the plant of the Toronto Paper Company at Cornwall at 600 volts. This plant was later taken over by the Howard Smith Paper Mills, Limited, and is now operated by that Company. During the year 1919 the power supplyfrom Winchester to Chesterville

was altered and a new station built at Chesterville.

In 1920 the operations continued along similar lines. The year 1921 was marked by great expansion, the municipalities of Alexandria, Maxville, Apple Hill, Martintown and Lancaster joined the St. Lawrence System, and received a supply of power. The Williamsburg supply was also altered in this year.

A large consumer, the Cornwall Pulp and Paper Company, was taken on in 1921 supplied by a short line from the Cornwall substation. This Company met with difficulties and went into liquidation, and the accounts for power under a contract with the Commission were not collected, except for a small initial payment.

In 1922, considerable extensions and changes were made in the System. Negotiations with a large consumer of power, the Eugene F. Phillips Electrical Company, Limited, were concluded, this Company having moved its works from Montreal to Brockville. The transmission lines to Brockville were re-modelled and strengthened, and the voltage of the System was changed to 44,000 volts by star-connecting the new and larger transformers which were installed at the Cornwall substation. Certain rural lines were also constructed from Chesterville and Brockville in this year.

At the present time about ten municipalities are being supplied by the System as well as a small number of individual consumers some of whom require large blocks of power.

In connection with the rural lines it may be well to note that the Ontario Government has a special Act, known as the Rural Hydro-Electric Distribution Act, 1921, whereby it may provide up to one-half the capital necessary for

primary rural lines under certain conditions. Section 4 of the Act reads as follows:

> "Where power is supplied to a rural power district under the provisions of the Power Commission Act and amendments thereto there may be paid to the municipality or commission distributing the power in such rural power district under the recommendation of the Hydro-Electric Power Commission of Ontario, and the order of the Lieutenant-Governor in Council, a sum not exceeding fifty per cent. of the capital cost of constructing and erecting in the rural power zone, primary transmission lines and cables required for the delivery of power in such rural power district."

Description of the System.

General.

The St. Lawrence System may be briefly described as that serving the district adjacent to the St. Lawrence River, comprising portions of the Counties of Glengarry, Stormont, Dundas, Grenville and Leeds. At the present time the transmission lines extend from Alexandria on the east to Brockville on the west, and northwards from the river front as far as Maxville, Chesterville and Winchester.

The map included as a frontispiece shows the whole of the transmission systems of the Hydro-Electric Power Commission of Ontario with the location of generating stations, high voltage transformer stations, high voltage transmission lines and low voltage transformer stations clearly indicated, and shows the various systems in their relation to one another. The tinted portion of the map indicates the St. Lawrence System.

The map included as page 10 shows the St. Lawrence System on a larger scale than the frontispiece and also gives the names of the principal centres concerned. It also shows the Ottawa System and the Rideau System which are adjacent to the St. Lawrence System to the northwards, and which at some time may be inter-connected with it.

Speaking broadly, the St. Lawrence System consists of a large transforming station situated near Cornwall, a system of transmission lines and transforming stations serving ten municipalities, and some rural lines.

Generating Station and Other Sources of Power Supply.

Strictly speaking there are no local generating stations which are used as a regular source of supply for the St. Lawrence System. As the entire power supply is purchased for use on this System the main receiving and transforming station near Cornwall may be considered as the point of generation for the St. Lawrence System. Until 1922 this station contained four 1,250 K.V.A., transformers stepping down the voltage from 110,000 volts to 26,400 volts. During 1922 these transformers were replaced by four others each of 5,000 K.V.A., capacity which are now so connected as to give 44,000 volts on the secondary, or low voltage side. The station has been remodelled where necessary to suit the new transformers and is amply large at the present time to serve the needs of the district for some time to come.

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
RIDEAU, ST. LAWRENCE AND
OTTAWA SYSTEMS

MAP SHOWING LOCATION OF GENERATING STATIONS, TRANSFORMER STATIONS AND TRANSMISSION LINES

Toronto, Feb 15th., 1923. Made by S.R.W., Checked by W.J.F.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Miscellaneous Power Plants in the District.

As already indicated in the text, power was formerly purchased from a number of small plants in the district, and from 1918 to 1922 three different sources of supply were used for this purpose. Prior to 1918, the New York and Ontario Power Company had also been called upon for the supply of power for a short period. The following table shows the amount of power which has been purchased since 1918 from various sources:

Table of Purchased Power Data

Source of Supply	Horse-power Purchased for each Fiscal Year Ending October 31st.				
	1918	1919	1920	1921	1922
M. F. Beach	524	272	-	-	-
Village of Morrisburg	17	22	19	3	-
Cedars Rapids Transmission Co.	-	772	2,230	3,093	3,736
Totals	541	1,066	2,249	3,096	3,736
Kilowatt-hours Purchased	-	-	8,478,500	10,793,000	14,652,500

These plants are not the only ones which are installed at various places in the district, and a table has been prepared showing the miscellaneous power plants in the St. Lawrence System territory. Some of these have been closed down due to the former owners becoming partners in the St. Lawrence System, and in some cases these plants are available as emergency stand-by plants for local use.

The municipalities of Cardinal, Casselman, Cornwall, Gananoque, Iroquois and Kingston Mills, not being partners in the St. Lawrence System, are still

supplied from the local sources indicated in the table shown on this page, which gives the location, size and ownership of the various plants in the district.

Table of Miscellaneous Power Plants in St. Lawrence System Territory

Location	Kind of Power	Approximate H.P.	River	Owner and Remarks
Alexandria	Steam	150	-	Municipal (Closed)
Brockville	Steam	1,100	-	Municipal (Closed)
Cardinal	Steam	400	-	Canada Starch Co. (Supplies C. S. Co., and Cardinal Electric Light Company).
Casselman	Water	450	South Nation	J. N. Coupal, (6 or 7 months' power).
Cornwall	Water	150	St. L. Canal System	Stormont Electric Light & Power Company.
Mille Roches (near Cornwall)	Water	2,500	St. L. Canal System	St. Lawrence Power Company, (supplies several places).
Gananoque	Water	200 (D.C.)	Gananoque	Gananoque Electric Light and Water Supply Company.
Gananoque	Steam	200 (D.C.)	Gananoque	Gananoque Electric Light and Water Supply Company.
Iroquois	Water	200	St. L. Canal System	Municipal. (No excess capacity)
Iroquois	Water	500	St. L. Canal System	M. F. Beach. (Future capacity said to be 2,500 H.P., supplies several places).
Kingston Mills	Water	800	Cataraqui Creek	Gananoque Electric Light and Water Supply Company. (Supplies Gananoque)
Morrisburg	Water	300	St. L. Canal System	#1 Municipal
Morrisburg	Water	1,200	St. L. Canal System	#2 Municipal
Prescott	Steam	225	-	Municipal. (Emergency stand-by)

Note: The voltages for all of these plants are 2,200, 2,300 or 2,400 at 60-cycles, except in the case of the Gananoque plants at Gananoque which are equipped with direct current generators at low voltage.

Omitting the steam plants at Alexandria, Brockville, Cardinal and Prescott, and the direct-current plants at Gananoque, the above table shows that there is an amount of approximately 6,500 horse-power available in developed hydro-electric plants in the district supplied by the St. Lawrence System, with a future capacity of about 9,000 horse-power if the Beach plant at Iroquois were developed to the full extent said to be possible. It is interesting to note that in 1917 and 1918 these plants supplied about 2,500 customers.

The St. Lawrence Power Company, which is stated to be a subsidiary of the Cedars Rapids Transmission Company, has substations at: Cornwall, 1,250 horse-power; Mille Roches, 800 horse-power; Moulinette, 10 horse-power; Wales, 50 horse-power; Dickinson's Landing, 50 horse-power; and also supplies lighting to the Government canals to the extent of 400 horse-power. It is understood that this total load of approximately 2,500 horse-power is now supplied from the transmission lines of the Cedars Rapids Transmission Company, and that the plant at Mille Roches is idle.

The plant of the M. F. Beach Company at Iroquois now has a capacity of about 500 horse-power, but it is stated by the owner, and by his consulting engineers that this can be made to supply 2,500 horse-power by taking full advantage of the available water supply from the canal. It is understood that this Company is now in dispute with the Hydro-Electric Power Commission of Ontario in connection with certain phases of the power supply formerly given by this Company to the St. Lawrence System, and that a sole arbitrator, Mr. J. M. Robertson, M.E.I.C., of Montreal, has recently been appointed to decide the questions in dispute. The Beach Company also operates a rural system

extending northwards towards Chesterville from Iroquois, and the owner has stated that he desires to obtain governmental assistance in the construction of his rural system on the same basis as that allowed for other rural lines constructed by the Hydro-Electric Power Commission. This matter will be referred to later under the discussion of the local market conditions.

It is understood that the larger plant in Morrisburg is idle at present, and that the Kingston Mills plant supplying Gananoque has some spare capacity.

Transmission Lines.

Up to October 31st, 1922, the Hydro-Electric Power Commission was operating high voltage transmission lines forming a 44,000-volt system from Alexandria on the east to Brockville on the west, with a number of branches to such points as Winchester, Chesterville, and so on. The map on page 10 shows the transmission system in detail. A few localities are supplied by means of the usual rural lines. The transmission system comprises a total of about 144 miles of lines constructed on wooden poles, and presents no extraordinary features. Considerable extensions to the rural lines are contemplated for 1923, and in this connection the proposals of the M. F. Beach Company should also be considered.

Transforming and Distributing Stations.

The transmission system feeds the various municipalities and individual consumers at low voltage through substations, which are listed in the following table, showing their voltage and capacity. It will be noted that a number of

these are of noticeable magnitude. Included in the table for convenience of reference is the main Cornwall receiving station from the Cedars Rapids Transmission Company which supplies power for the whole system.

The table is as follows:

Table of Transformer Stations

Location	K.V.A. Capacity	Voltage H.V.	Voltage L.V.	Remarks
Cornwall	4 at 5,000	110,000	44,000	Replacing 4 at 1,250 K.V.A.
Cornwall (reserve)	750	44,000	2,400	
Alexandria	300	44,000	4,160	
Apple Hill	300	44,000	4,160	Supplies Maxville
Cornwall Pulp & Paper Co.	2,250	44,000	600	
Toronto Paper Co.	1,500	44,000	300	
Martintown	150	44,000	4,160	Supplies Lancaster.
Williamsburg	50	44,000	2,400	
Brockville	1,500	44,000	2,300	
Winchester	150	44,000	4,160	
Chesterville	300	44,000	4,160	
Prescott	450	44,000	2,300	

Local Distributing Systems.

With the exception of the rural lines already mentioned and sundry individual customers such as the Howard Smith Paper Mills, Limited, there are no municipalities on the St. Lawrence System in which the Hydro-Electric Power Commission distributes retail power to the consumers. The Commission acts as a wholesale distributor and in all the municipalities the electricity is distributed by the municipality itself or by local commissions in the municipalities. It is understood that the accounting for all of the municipalities of

the St. Lawrence System is done in accordance with the standard accounting system of the Hydro-Electric Power Commission, and the details for the various municipalities are given in the Annual Reports.

Characteristics of Market.

Population Served and Percentage of Consumers to Population.

The district served by the St. Lawrence System is both urban and rural, the bulk of the load being in the various municipalities, most of which are quite small, Brockville with about 7,000 population being the only place having more than 3,000 people. Cornwall is not a partner in the St. Lawrence System.

"Municipal Statistics" of the Province of Ontario for 1921 gives a total population of about 85,000 for those portions of the Counties of Glengarry, Stormont, Dundas, Grenville and Leeds, which are tributary to the St. Lawrence System. Deducting from this, 10,000 persons in towns now served by other power systems, there remains a tributary population of about 75,000 as at October 31st, 1921. At that date the total population in the ten municipalities served by the System was about 18,500 persons, with about 3,800 consumers. As the larger centres are already supplied, the greater part of the remainder of the tributary population can only be supplied by a fairly extensive system of rural lines. Excluding the Howard Smith Paper Mills, Limited, the ten municipalities now served were billed with about 1,675 horse-power in 1921, or

about 2,640 horse-power including this consumer. In 1922 the total power billed, including the individual consumers, was almost 4,000 horse-power. In 1923 the billed power will probably increase by 1,500 horse-power or more, made up largely of the load of the Eugene F. Phillips Electrical Works, Limited, at Brockville. This Company, it is understood, commenced to take power about November, 1922, and the contract contemplates that they will take power up to about 2,500 horse-power, with a probable minimum of 1,000 or 1,100 horse-power. The normal growth of the System will doubtless account for several hundred horse-power in addition.

The Cornwall Pulp and Paper Company, which was connected in 1921, and which was to have taken from 1,000 to 2,[illegible] horse-power, went into liquidation, and the power taken by this consumer was not included in the figures for the above-mentioned loads.

The table on the following page gives in detail the number of consumers at the end of the fiscal year 1921 in the places served by the Commission, the approximate horse-power billed to each place in 1921, the kilowatt-hours supplied to the System in 1921, and the average horse-power per consumer in 1921. The figures are useful for comparison with other systems, although they should be used with caution.

Table of Market Statistics

Consumer	Population	No. of Consumers	Percentage Consumers to Population	H.P. Billed 1921	Kilowatt-hours 1921	Billed H.P. per Consumer	Kilowatt-hours per Consumer
Alexandria	2,275	303	13.3	96.2	-	0.32	-
Apple Hill	300 abt.	44	-	5.7	-	0.13	-
Brockville	9,254	2,087	22.5	1,073.9	3,499,200	0.52	1,690
Chesterville	919	202	22.0	150.9	-	0.75	-
Lancaster	639	66	10.3	6.1	-	0.09	-
Martintown	300 abt.	45	-	3.4	-	0.08	-
Maxville	721	125	17.3	19.6	-	0.16	-
Prescott	2,758	617	22.4	216.1	-	0.35	-
Williamsburg	200	70	35.0	11.5	-	0.16	-
Winchester	1,208	263	21.8	90.9	-	0.35	-
Jas. Robertson	-	-	-	0.3	-	-	-
H.S. Paper Mill	-	-	-	944.9	-	-	-
Totals	18,574	3,802	20.5	2,639.5	10,793,000	0.69	2,840

COPY

* Supplied to System

The average horse-power billed per consumer and per capita, and the average kilowatt-hours per consumer and per capita are as follows:

Average Horse-power Billed per Consumer	0.69
Average Horse-power Billed per Capita	0.14
Average K.W.H. Consumed per Consumer	2,840
Average K.W.H. Consumed per Capita	590

Growth of Market and Ultimate Sources of Power Supply.

Since the commencement of power supply in 1913 and 1914 up to the end of 1918, the actual amount of power used on the System was less than 600 horse-power. Since the end of 1918, the growth of the load has been remarkably rapid, the maximum peak for 1919 was 1,600 horse-power; for 1920, 2,450 horse-power; for 1921, 4,800 horse-power; and for 1922, 4,908 horse-power. The 1922 load

does not include the Phillips Company's load at Brockville as the figures are given for the fiscal years ending October 31st, and that consumer had not then taken power. The reason for the sharp increase in load in 1921 is largely due to the additional municipalities served. As already pointed out, the addition of the Phillips Company's load for 1923 may add from 1,000 to 2,000 horse-power to the total demands, and with the normal growth of service in the district the peak demand for 1923 may possibly be 7,000 horse-power.

The problem of serving rural customers is difficult, the average number of consumers per mile of transmission line being small. The experience of the Hydro-Electric Power Commission of Ontario up to the present time indicates that only three or four consumers per mile on the average are obtainable.

It will be noted from the table of market statistics that the percentage of consumers to population served at the end of 1921 was about 20.5.

The situation at the present time is that the St. Lawrence System has a large excess of available power at its main Cornwall transformer station, and that there are many places in the district which do not yet receive power from the Hydro-Electric Power Commission. In certain centres the people are apparently quite satisfied to continue under their present private arrangements, and in some of the places already mentioned it will apparently be difficult for the St. Lawrence System to obtain these municipalities as partners.

The question of ultimate use of power on the System, and of the future ultimate source of power supply for the whole of the population, is one which depends partly on the relations of the local private companies and the municipalities to the Hydro-Electric Power Commission. From the table of

miscellaneous power plants in the St. Lawrence System territory, shown on page 12, and from the fact that large new power developments are contemplated within commercial transmission distance, it is evident that a comparatively large capacity in private power plants could be made available to serve the district in competition with the Hydro-Electric Power Commission of Ontario. Some dissatisfaction has been privately and publicly expressed with the Hydro-Electric Power Commission of Ontario in the district, and there is apparently a widespread feeling of sympathy in the district for the continuation of private ownership and fixed rates. The M. F. Beach Company, for example, has made certain definite offers to supply power to certain places at fixed prices over a term of years. If the stated future capacity of this Company be realized it will doubtless be sufficient to supply a large mileage of rural lines and serve a large population with power, possibly paralleling the lines of the Hydro-Electric Power Commission in several places. From the view point of the rural consumer the question of who supplies the power is not nearly so important as the total cost of the service. Arguments have been advanced by some of the rural inhabitants that the Ontario Government should give the same assistance to the Beach Company's rural lines as would be done for the rural lines of the Hydro-Electric Power Commission, especially as this Company is said to be prepared to make satisfactory contracts at fixed rates for the rural areas contemplated. Some solution of the problem, for example, co-operation, should be found whereby unnecessary duplication of transmission systems may be avoided, and at the same time permit those who wish to receive power from sources not now controlled by the Hydro-Electric Power Commission to do so under terms

satisfactory to the consumer and to the supplying company. The purchase of power from the Beach plant at Iroquois by the Hydro-Electric Power Commission might be considered and the taking over and extending of the rural system now owned by the Beach Company, paying a fair price for the power supplied from the Beach plant and distributing it in the usual way to the rural consumers. An objection to this from the view point of the Hydro-Electric Power Commission would probably be that they now have a substation near Cornwall of ample capacity for the whole System, and that they have rural lines under construction, or contemplated, to serve the whole System. Even with the help of the Provincial Government grant of one-half the capital cost of the primary rural transmission lines, the problem of serving rural customers satisfactorily is very difficult of solution and is complicated in this section of the Province owing to the presence of competitive privately-owned systems. An alternative solution might be the purchase of the Beach interests as a whole.

The ultimate source of power supply for the St. Lawrence System when all the available local plants will have been used to full capacity, or else discarded, is undoubtedly transmitted power either from the Cedars Rapids plant or from other large plants contemplated at Carillon, Chats Falls and Bryson on the Ottawa River, or at the Chelsea and the Paugan sites on the Gatineau River, where large amounts of power aggregating several hundred thousand horsepower can be made available. The proposed development of the St. Lawrence River powers would doubtless provide all the power necessary for the St. Lawrence System for all time to come, but these developments are not likely to be completed for many years.

If the Rideau System and the Ottawa System be extended southwards and eastwards, and the St. Lawrence System be extended northwards, it is possible that in the future inter-connecting lines may be constructed so that any of these systems might receive power either from the water powers on the St. Lawrence River or from the Ottawa and Gatineau Rivers.

The present indications are that the actual total amount of power used on the St. Lawrence System will not reach the present capacity of the transforming station near Cornwall for many years to come.

Capital Costs.

General.

The capital costs of the St. Lawrence System have increased rapidly year by year as the System has been extended and brought up to date. Up to the end of 1921 the total capital costs of the System amounted to about $854,000, and it is understood that at the end of the fiscal year 1922 the total investment is approximately $1,100,000, but the details for 1922 are not yet available. Of the 1922 expenditures it is understood that about $45,000 represents money spent on rural lines, and that about $115,000 was spent in extending and strengthening and re-modelling the transmission system from Cornwall to Brockville, and about $100,000 on the extensions to the Cornwall station and miscellaneous betterments.

The figures of capital costs given in the table below and plotted

diagrammatically, and shown on the sheet of curves on page 24 were obtained from the report of Price, Waterhouse & Co. to the Hydro-Electric Inquiry Commission under date of November 7th, 1922, Hydro-Electric Inquiry Commission file No. 200-a, for the years from 1917 to 1921 inclusive, while the figures for 1912 to 1916 inclusive were obtained from the Annual Reports of the Hydro-Electric Power Commission. The table is as follows:

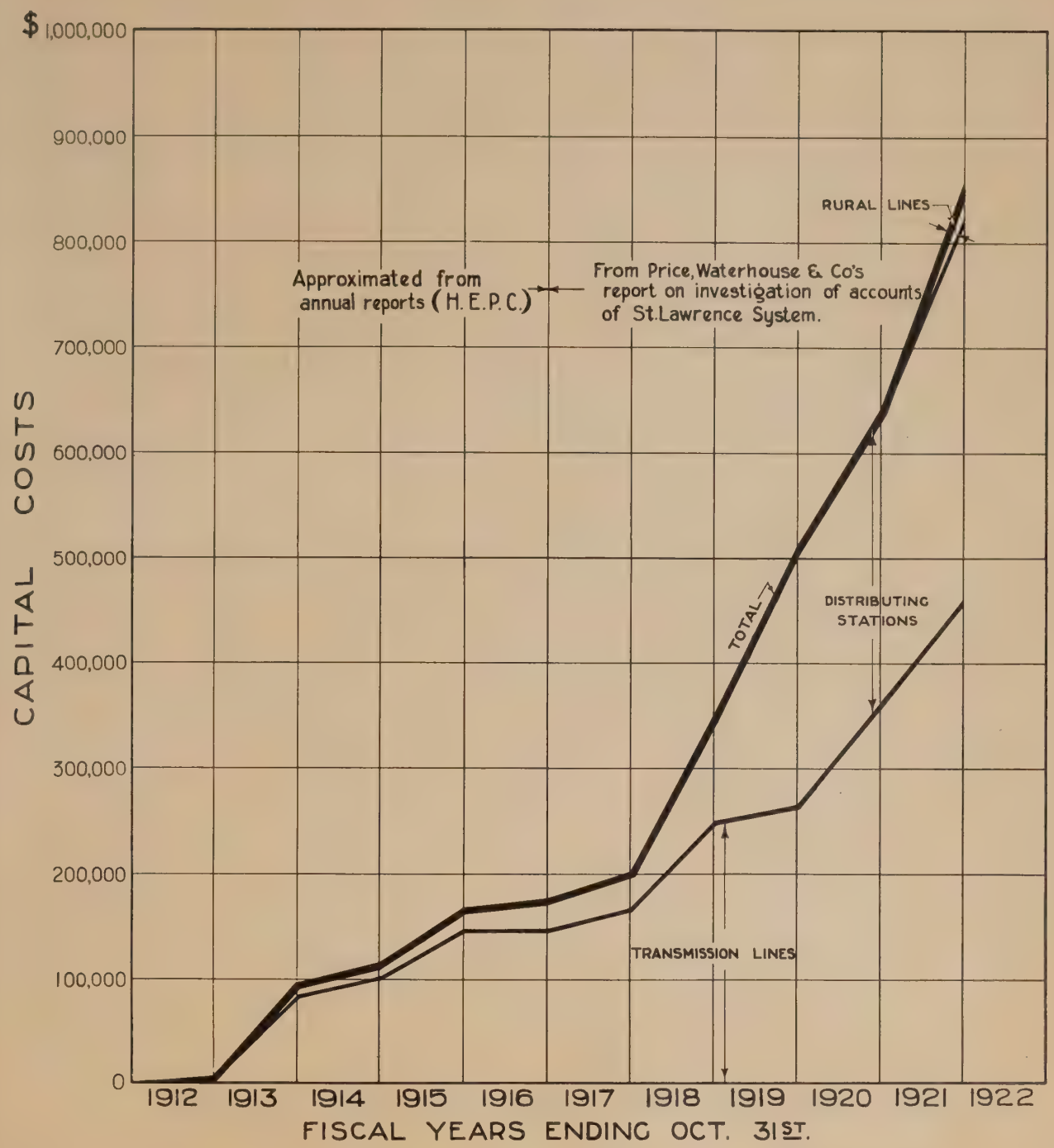
Table of Progressive Capital Costs

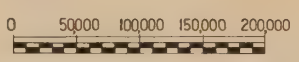
Capital Assets	As at Year Ending October 31st, 1912	1913	1914	1915	1916
Transmission Lines	$ 6,614	$ 90,755	$105,791	$147,652	$147,229
Transformer Stations	10	2,911	9,727	20,955	29,429
Rural Lines	-	-	-	-	-
Totals	$ 6,624	$ 93,666	$115,518	$168,607	$176,658

Table of Progressive Capital Costs (continued)

Capital Assets	As at Year Ending October 31st, 1917	1918	1919	1920	1921
Transmission Lines	$167,418	$250,448	$265,541	$363,732	$462,695
Transformer Stations	33,892	99,716	247,825	277,401	378,370
Rural Lines	-	-	-	-	13,129
Totals	$201,310	$350,164	$513,366	$641,133	$854,194

It is understood that considerable capital cost is anticipated for 1923, amounting to approximately $75,000 for extensions to miscellaneous stations and lines, and $50,000 for rural lines. If these extensions be made the total investment in the St. Lawrence System at the end of the fiscal year 1923 will





HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM

PROGRESSIVE CAPITAL COSTS

Toronto, Feb. 15th, 1923. Made by W.D. Checked by L.D.H.

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be approximately one and one-quarter millions of dollars. Judging by the recommendation of the Commission in the past, it is probable that it will recommend that the Government pay one-half the cost of the rural primary lines, and it is understood that the above figures take these allowances into consideration.

The capital expenditures were made largely at times of high prices. The main receiving station has been constructed for a capacity several times larger than the present load, and the distances between consuming points on the System has resulted in a large mileage of lines built for comparatively small present requirements. The total capital costs are therefore comparatively heavy for the actual use of power on the System at present, and until loads are considerably heavier this will form somewhat of a burden on the municipalities served, especially in the smaller places where the demand is very light.

Power Data.

The table on the following page, and the sheet of curves on page 27 have been prepared to show the characteristics of the St. Lawrence System in terms of horse-power. The figures are as follows:

Table of Horse-power Developed, Consumed, Billed, etc.

		1918	1919	1920	1921	1922
H.P. Purchased		541	1,066	2,249	3,096	3,736
H.P. Average Consumed by System		-	-	1,300	1,653	2,244
H.P. Billed to Consumer		717.3	1,248.2	2,123.7	2,639.5	3,993
H.P. Average of Twelve Monthly Peaks		538.8	1,020	2,153	3,120	3,736
H.P. Maximum Yearly Peak	(a)	566.7	1,600	2,450	4,800	4,908
	(b)	18.5				

(a) from M.P. Beach (b) from Morrisburg

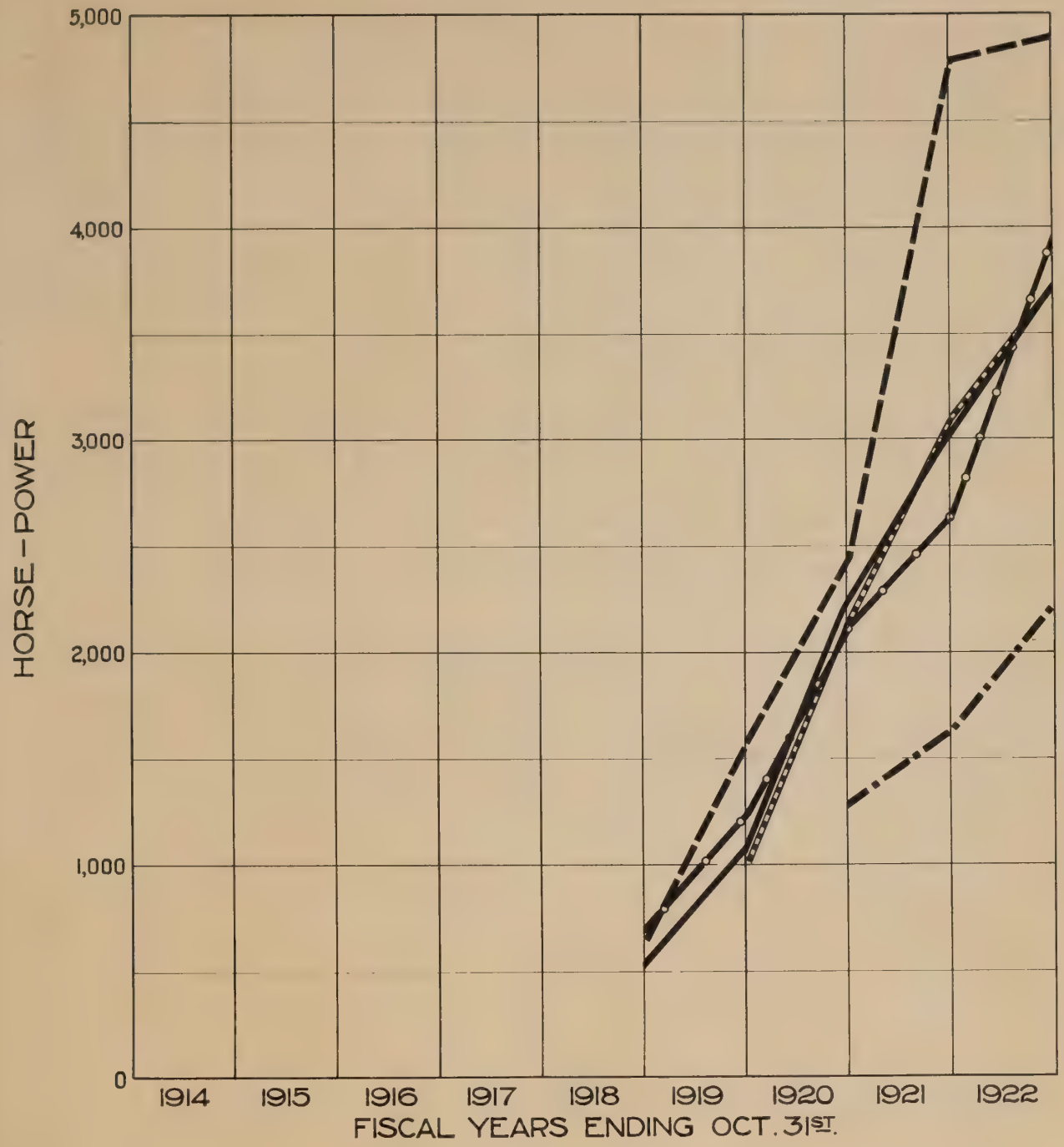
It will be noted that there are five classes of horse-power shown on the table and in the diagrams. These may be explained as follows:

Purchased Horse-power.

The figures for plotting the curves showing the purchased horse-power were obtained from the records of the Hydro-Electric Power Commission and represent the amount purchased from each source of supply in each of the years 1918 to 1922.

Average Horse-power Consumed by System.

The average horse-power consumed by the System has been derived from the total number of kilowatt-hours stated by the Hydro-Electric Power Commission as being the total supply to the St. Lawrence System for the three years ending October 31st, 1920, 1921 and 1922. The derivation was made by dividing



0 500 1000
VIRTICAL SCALE — H. P.

MAXIMUM YEARLY PEAK
AVERAGE OF 12 MONTHLY PEAKS
HORSE-POWER PURCHASED
HORSE-POWER BILLED PER ANNUM
HORSE-POWER, AVERAGE CONSUMED (TAKEN BY SYSTEM)

HYDRO-ELECTRIC INQUIRY COMMISSION
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ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
ST. LAWRENCE SYSTEM

HORSE-POWER DATA

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the total kilowatt-hours per annum by 8,760, being the number of hours in a year, and reducing to horse-power by dividing by the factor 0.746.

Billed Horse-power.

The curve of billed horse-power was plotted from data given in the report of Price, Waterhouse & Co., already referred to, and is the amount charged to consumers on the System.

Average Monthly Peaks.

The curve of average monthly peaks was obtained by taking the average of the twelve monthly maximum peaks for each year as shown in the records of the Hydro-Electric Power Commission of Ontario, and dividing the sum of the monthly peaks by twelve to get a yearly average monthly peak. Each of these averages was then plotted as a single point for the average monthly peak of each year.

Maximum Yearly Peaks.

The curve showing the maximum yearly peaks was plotted directly from the maximum peak indicated for each year from the same source as used for the derivation of the curve of average monthly peaks.

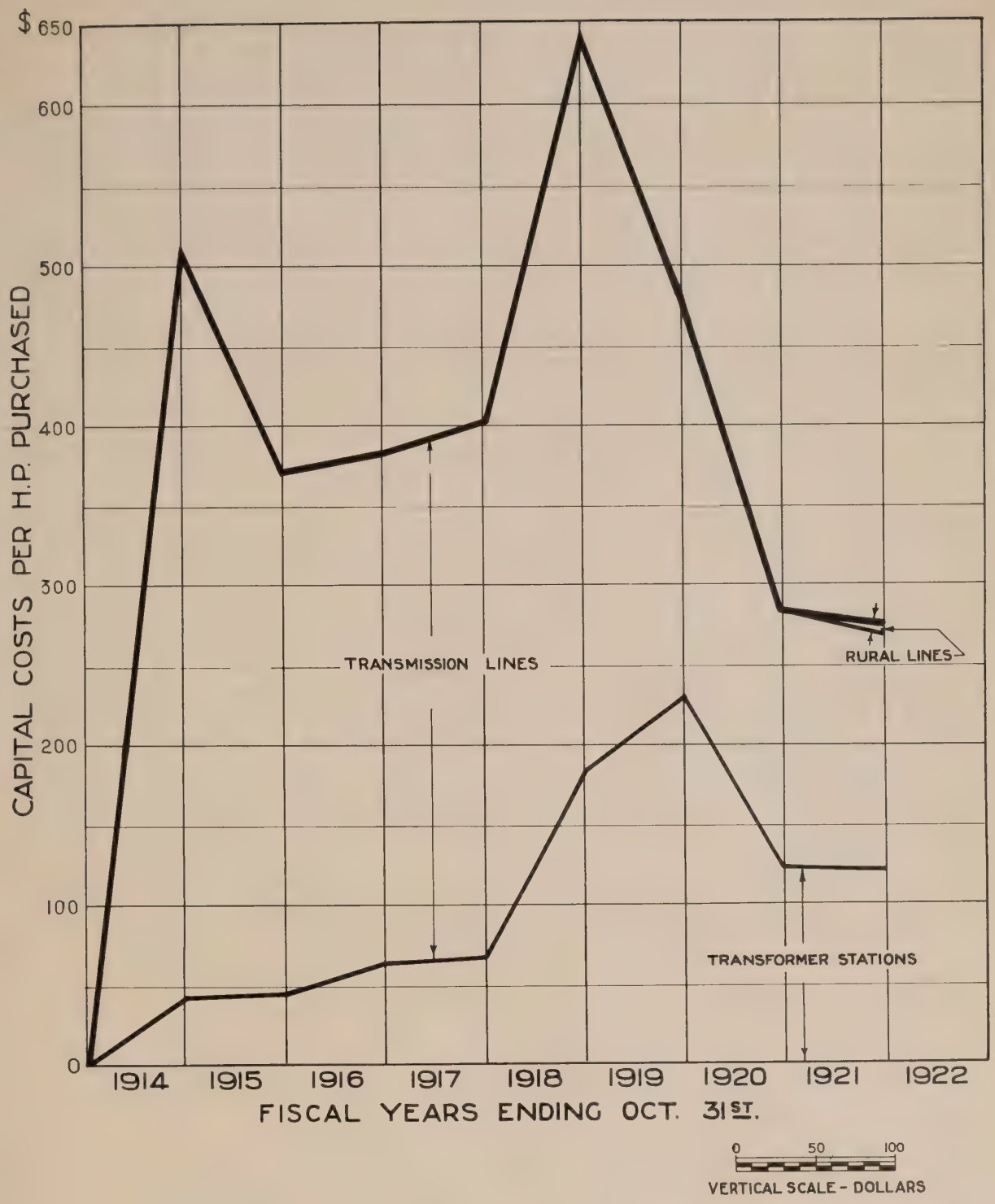
Capital Costs per Horse-power Purchased.

The table below and the sheet of curves included as page 30 indicate the fractional capital costs per horse-power purchased from the year 1914 to 1921 inclusive for different points of delivery, based on the figures showing the capital costs of the System and the horse-power data given above. The sheet of curves therefore indicates the capital costs per horse-power purchased, with the spaces between adjacent curves indicating that portion of the total delivered capital cost per horse-power chargeable against each of the items of the table, as follows:

Table of Capital Costs per Horse-power Purchased

	1914	1915	1916	1917	1918	1919	1920	1921
Transformer Stations	$43	$ 46	$ 64	$ 68	$184	$232	$123	$122
Transmission Lines	468	328	320	334	463	249	162	150
Rural Lines	-	-	-	-	-	-	-	4
Totals	$511	$374	$384	$402	$647	$481	$285	$276

It will be noted that in the capital costs per horse-power nothing is shown for generating stations as there are none on the System, but the figures include the cost of the Cornwall receiving station with the other transformer stations. The apparently high capital costs per horse-power are due to the large capacity of the main receiving station, the length of the necessary transmission lines to serve all the municipalities in the partnership and the small amount of power required at present. As the power purchased increases,



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ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM

CAPITAL COSTS
PER HORSE-POWER PURCHASED

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the capital costs per horse-power should fall rapidly.

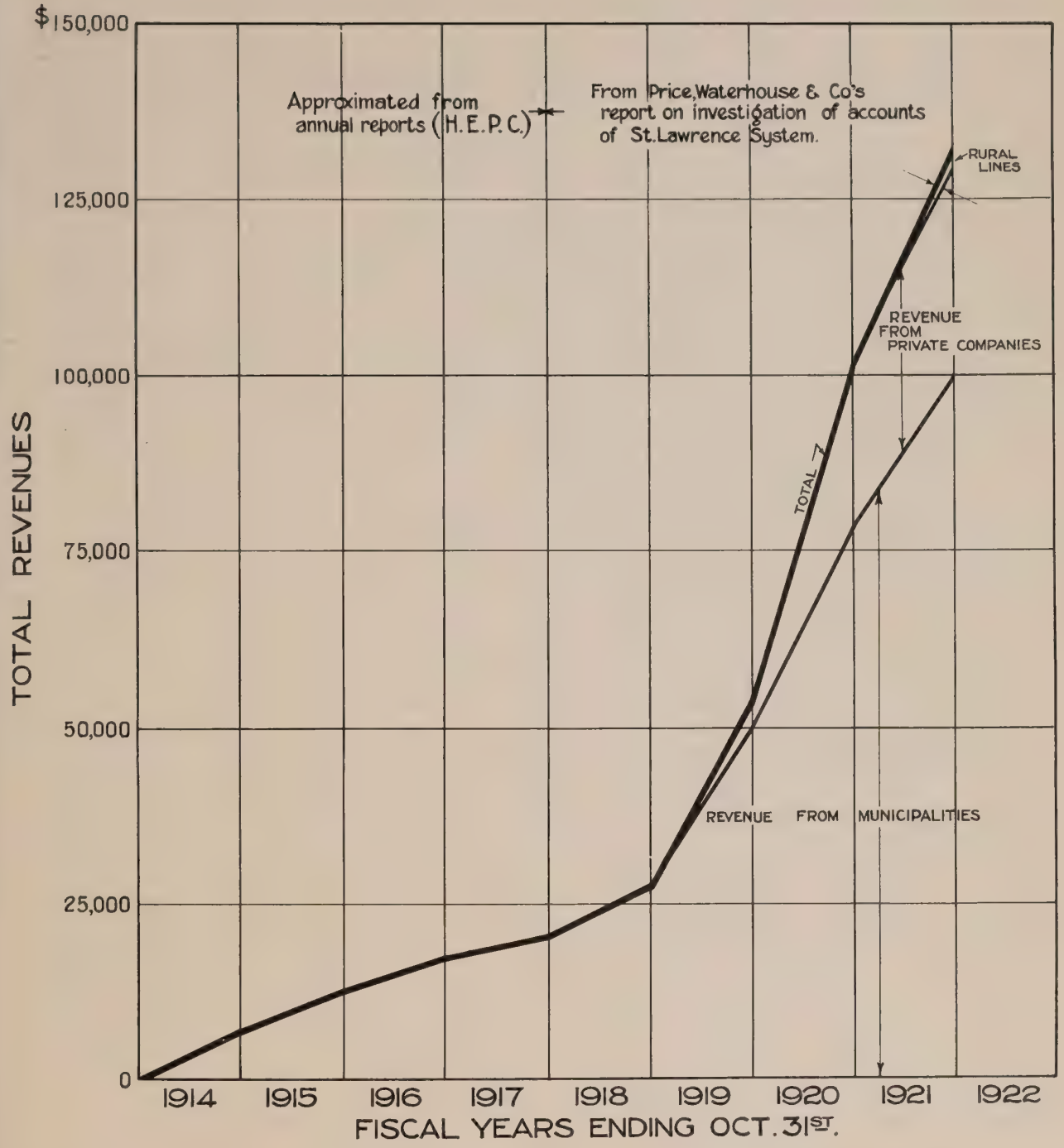
If it be desired to obtain the capital costs per horse-power installed, or in other words based on the capacity of the main receiving station, the total capital costs for the year 1918 to 1921 inclusive may be divided by approximately 5,000 which was the capacity of the transformers up to that time, and by the figure 30,000 for 1922 which is the present approximate installed capacity of the main receiving station.

Total Annual Revenues.

The following table, and the sheet of curves included as page 32 giving the total revenues of the St. Lawrence System have been prepared by using the figures given in the report of Price, Waterhouse & Co. already mentioned, for the years 1918 to 1921 inclusive. The figures for the revenues from 1914 to 1917 inclusive were taken from the Annual Reports of the Hydro-Electric Power Commission, and have been included in the sheet of curves showing the revenues, but were not tabulated. The figures are as follows:

Table of Total Revenues

	Fiscal Years Ending October 31st, 1918	1919	1920	1921
From Municipalities	$27,744.05	$50,043.76	$ 78,498.32	$100,026.83
From Private Companies	-	3,969.00	22,870.72	32,966.30
Rural Lines	-	-	-	311.03
Totals	$27,744.05	$54,012.76	$101,369.04	$133,304.16



HYDRO-ELECTRIC INQUIRY COMMISSION
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ECONOMICS OF H.E.P.C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM

TOTAL ANNUAL REVENUES

Toronto, Feb. 10th., 1923. Made by G.E.B. Checked by L.L.

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Total Annual Costs of Power.

The table on page 35 shows the cost of power subdivided under various headings for the years 1918 to 1921 inclusive, while the sheet of curves included as page 36 shows these figures plotted in graphic form. It will be noted that on the sheet of curves the total costs for the years 1914 to 1917 are indicated for comparison, these figures having been obtained from the Annual Reports of the Hydro-Electric Power Commission.

The headings under which the various costs have been grouped are as follows:

COPY

Power Purchased.

A separate heading for power purchased has been included for the reason that there is no power generated on this System by the Commission, and the power purchased is the largest single item of the annual costs of power. The figure shown for each year since 1918 is the total amount of the charges for power purchased from the Cedars Rapids Transmission Company.

Operating Costs.

Operating costs include the wages of transforming and distributing station operators, linemen, attendants and so forth, supplies and miscellaneous items usually grouped under this heading.

Maintenance.

Under maintenance have been placed all the items for labour and materials charged in the books of the Commission as against the individual portions of the System, stations, lines and distributing stations, and these have been grouped together from the individual figures in the Price, Waterhouse & Co. report to make one item.

Overhead and General Expense.

Under the heading of overhead and general expense are such items as salaries of local officers and clerks, printing and stationery, stores operation, taxes, insurance, rents, legal expense, miscellaneous office supplies and so forth, all in accordance with the Price, Waterhouse & Co. report.

Interest, Renewals, Sinking Fund and Contingencies.

The figures for interest include all interest charges shown for the capital invested in the System. The renewal account includes all items shown as chargeable against renewals in the same report, while the figures for sinking fund and for contingencies have been transferred directly from the report.

The figures for the various items are as follows:

Table of Total Annual Costs of Power

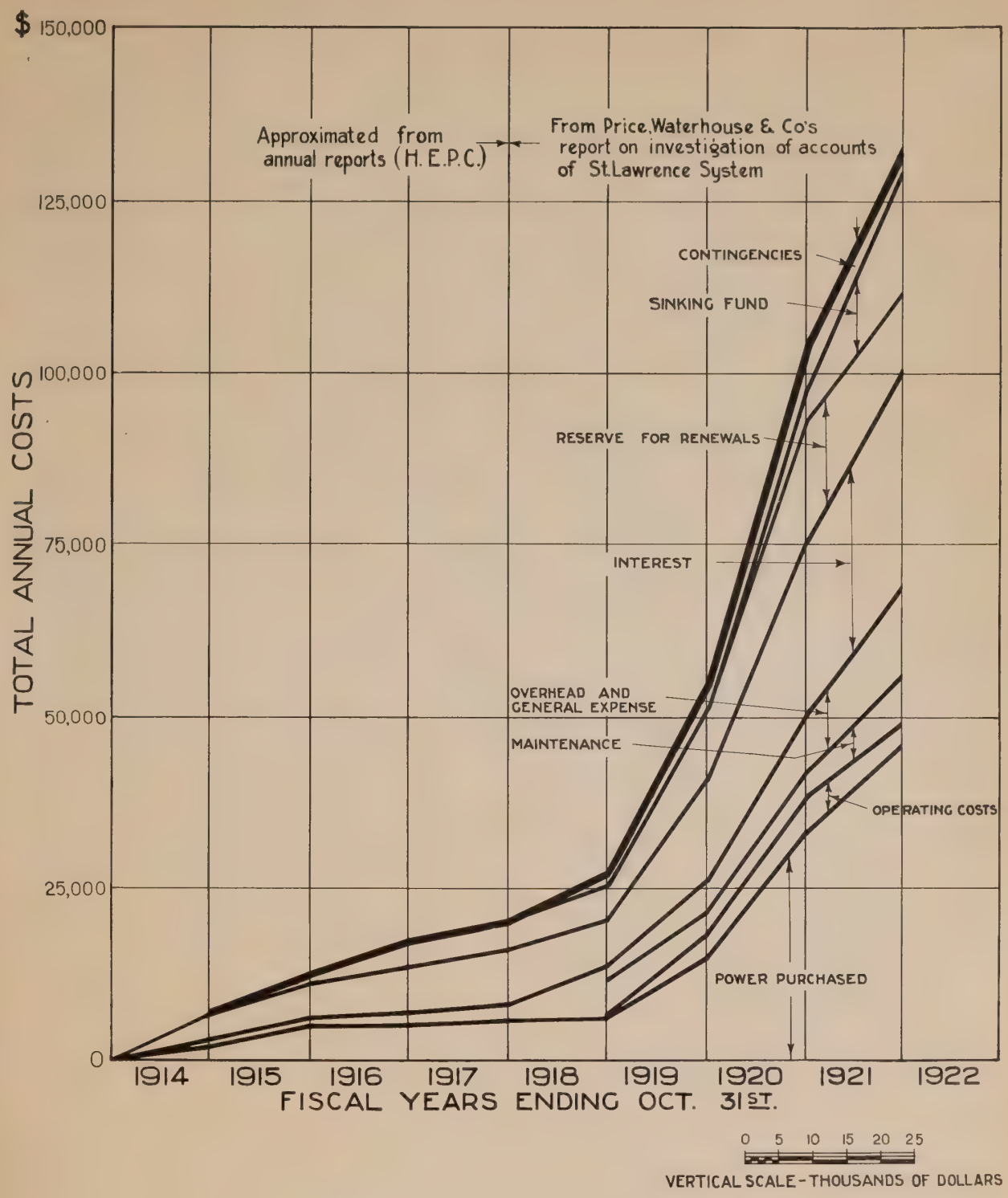
	1918	1919	1920	1921
Power Purchased	$6,560	$15,171	$ 33,711	$ 46,441
Operating Costs	411	3,601	5,051	3,055
Maintenance	5,035	3,039	3,411	7,011
Overhead and General Expense	1,897	4,646	8,473	12,753
Interest	6,831	14,702	24,528	31,760
Renewals	6,851	13,571	21,537	20,941
Sinking Fund	-	-	4,640	10,372
Contingencies	179	397	3,185	660
Totals	$27,744	$55,127	$104,536	$132,993

It will be noted that in 1919, 1920 and 1921 there are certain small differences between the total revenues and the total costs of power, namely losses of $1,114 in 1919, $3,167 in 1920, and $1,413 in 1921. It is understood that the first two items have been charged to the reserve for contingencies and that the loss in 1921 was charged against the various municipalities and included in the cost of power supplied to them.

In the discussion of revenues and costs nothing has been allowed as revenue from the Cornwall Pulp & Paper Company during 1921, but it is understood that the actual costs of supplying electrical energy to this Company was included in the costs of the System and apportioned to the various municipalities. For further discussion of this see pages 9 and 10 of the report of Messrs. Price, Waterhouse & Co. above mentioned.

Percentage Costs of Power.

The table on the following page and the sheet of curves included as page



HYDRO-ELECTRIC INQUIRY COMMISSION
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ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM

TOTAL ANNUAL COSTS

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38 shows the annual cost figures as percentages of the total cost of power per annum and these are included as a method of comparison with other systems or properties.

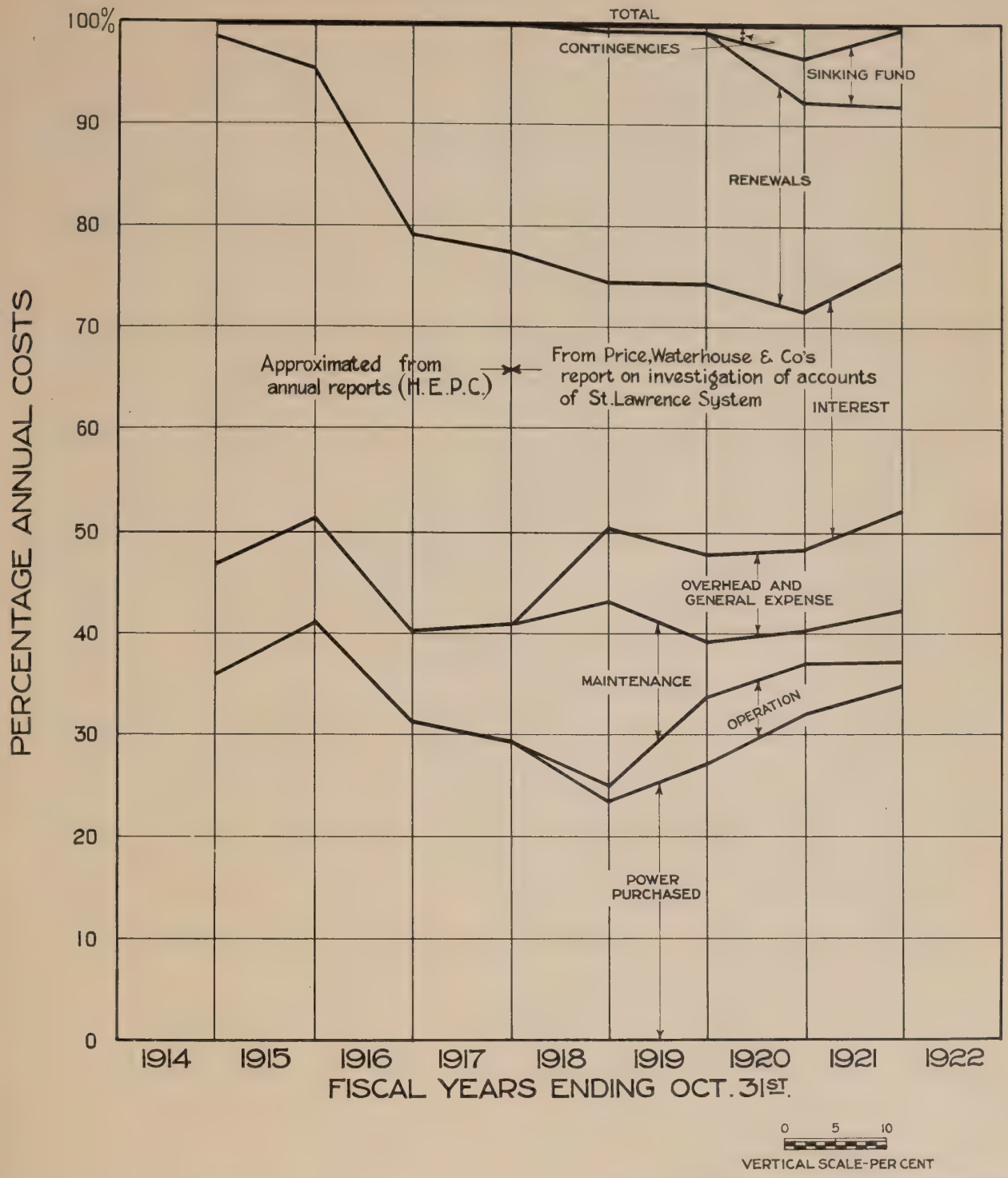
Table of Annual Costs Subdivided by Percentages

	1918	1919	1920	1921
Power Purchased	23.7	27.5	32.3	34.9
Operation	1.5	6.5	4.8	2.3
Maintenance	18.1	5.5	3.3	5.3
Overhead and General Expense	6.9	8.5	8.1	9.6
Interest	24.6	26.7	23.5	23.9
Reserve for Renewals	24.6	24.6	20.6	15.7
Sinking Fund	–	–	4.4	7.8
Reserve for Contingencies	0.6	0.7	3.0	0.5
Totals	100%	100%	100%	100%

Analysis of Reserve Accounts.

Renewals Account.

The renewal account originally set up for the St. Lawrence System was on a 4 per cent. sinking fund basis following the usual sinking fund method for providing a fund for equipment deteriorating in use. The useful life in years of each portion of the depreciable capital invested, the replacement cost, and the residual or scrap value of the articles at the end of this time are all estimated, and an amount is set aside which when compounded at an assumed earning rate will retire the total amount to be provided for at the end of the



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ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM

ANNUAL COSTS SUBDIVIDED BY PERCENTAGES

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estimated useful life. It is understood that it is the practice of the Hydro-Electric Power Commission to spend sufficient money on maintenance account each year so as to keep each and every portion of the System in a condition to operate in accordance with the requirements of economical production, which it is stated is considered to be about 75 per cent. as good as its original new condition. This being so, it was considered in this report that the renewal accounts should be studied in connection with and applied to the renewal of only 25 per cent. of the capital concerned.

The annual rate of 4 per cent. was based upon the original ideas of the engineers of the Hydro-Electric Power Commission, but in 1920 the basis was changed to 3 per cent. and adjustments were made in accordance with this change and made retroactive to 1914. As at October 31st, 1921, an adjustment making a reduction of $17,709.00 was made in the amounts reserved for renewals which had been included in the cost of power from 1914 to 1920. The table on page 41 and the sheet of curves on page 42 show the original reserve for renewals on the 4 per cent. basis and the reserve account on the 3 per cent. basis, together with the annual adjustment in the cost of power allowed from 1914 to 1920 inclusive. The table indicates the reserve for renewals allowances for 1921, and shows the total to October 31st, 1921, amounting to $76,195. To this figure was added a reserve applicable to equipment transferred from other systems amounting to $2,962 and from the total was deducted a sum applicable to equipment transferred to other systems, and for sundry replacements which, with interest, amounted to $2,798, so that the total credit of the fund at October 31st, 1921, amounted to $76,359. In determining the reduction of the

reserve account from 4 per cent. to 3 per cent., Messrs. Price, Waterhouse & Co. point out that clerical errors were made in the computations by the engineering department of the Hydro-Electric Power Commission of Ontario and they indicate that the figures should have been 2.098%. As a result of this arithmetical discrepancy it is stated that the engineers of the Hydro-Electric Power Commission have recommended a further reduction in the annual renewal rate, and a further retroactive adjustment of the whole reserve fund. This would have the effect of building up the reserve fund in future at a much slower rate and of correspondingly reducing the costs of power.

Two questions should receive consideration in dealing with these reserves for renewals, one is the proposed change in the estimated useful length of life of the various portions of equipment which will materially affect the annual allowances, and the other is the proper rate of interest to be chosen in estimating the earning power of the invested reserve funds.

A strict theory of the earning power of the renewal fund would take into consideration not only the method of investing the fund, for example, whether it be used in making extensions and betterments in the System as has actually been done, or invested in separate securities and treated like a trust fund, but also the rate of annual interest which should be adjusted each year in accordance with the actual value of the money. The legal limitations of the allowable investment of the fund should also be kept in mind in this connection.

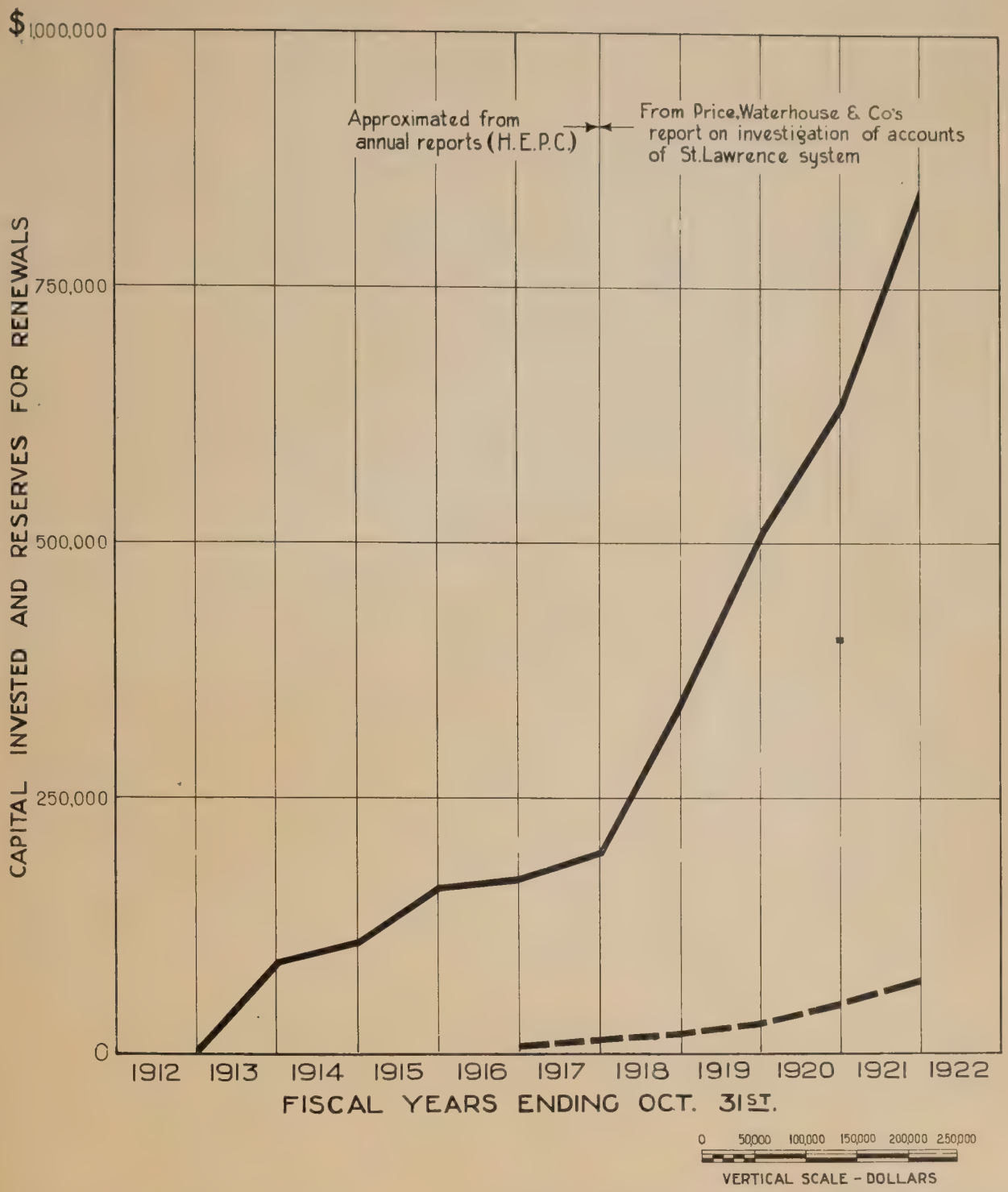
At the present time the total depreciable capital is probably about $1,000,000, while the reserve fund for renewals to the end of 1921 was about $76,000, and something over $100,000 at the end of 1922, assuming that the

same rates apply. As a large portion of the total depreciable capital has been invested within the past three or four years, and as the various portions of equipment have only been in service for a very brief period it would therefore appear that the present total accumulations of the fund as applicable to 25 per cent. of the total depreciable capital is somewhat larger than is necessary, taking all the above factors into consideration. The table showing the state of the reserve for renewals at October 31st, 1921, is as follows:

Table of Analysis of Reserve for Renewals

Fiscal Year	Reserve on 4% Basis			Reserve on 3% Basis			Amount of Adjustment		
	Net	Interest	Total	Net	Interest	Total	Net	Interest	Total
1914							1,123	-	1,123
1915	16,416	572	16,988	12,312	429	12,741	1,285	45	1,330
1916							1,696	98	1,794
1917	7,047	679	7,726	5,285	510	5,795	1,761	170	1,931
1918	6,831	988	7,819	5,123	741	5,864	1,708	247	1,955
1919	13,571	1,301	14,872	10,178	976	11,154	3,393	325	3,718
1920	21,537	1,896	23,433	16,153	1,422	17,575	5,394	474	5,858
	65,402	5,436	70,838	49,051	4,078	53,129	16,350	1,359	17,709
1921	-	-	-	20,941	2,125	23,066	-	-	-
Totals	-	-	-	69,992	6,203	76,195	-	-	-

It is a coincidence that the amount of the reduction in the reserve for renewal account, $17,709, is almost equal to the outstanding accounts for power of various municipalities and private consumers on the System, and also about equal to the bill owing by the Cornwall Pulp & Paper Company at the time of its liquidation. In Mr. Clarkson's report on the accounting of the System as at October 31st, 1921, comment is made on the amount owing by the Cornwall Pulp & Paper Company, Limited, which was stated to be about $17,622. Apparently no



TOTAL CAPITAL INVESTED
CAPITAL LESS RESIDUAL VALUE
RESERVE FOR RENEWALS ON 3% BASIS

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H.E.P.C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM

RESERVES FOR RENEWALS

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CONSULTING ENGINEERS

allowance was made for this sum in estimating the revenues but the actual costs for supplying the power for this Company are stated to have been charged to the various municipalities in 1921. If the costs of supply were equal to the amount owing, the practical effect of the credit made by the reduction in the reserve for renewals account would be to offset the debt of the Cornwall Pulp & Paper Company.

Price, Waterhouse & Co. state that at September 20th, 1922, the various municipalities still owed the System an aggregate sum of about $17,208, which was apparently the balance after having made allowance for certain reductions in their obligations to the System by crediting them with the above-mentioned adjustment of the reserve for renewals. See Exhibit V, and pages 20 and 21 of the report of Price, Waterhouse & Co. dated November 7th, 1922.

Sinking Fund.

The study of the finances of the System shows that about $15,197 has been set aside as sinking fund to provide for the financial obligations concerning the properties, and in addition about $195 in respect of rural lines.

At the end of 1921 less than one-half the municipalities served by the System came within the five-year limit of the provisions of the Power Commission Act, Section 23-B, and therefore only five of them had commenced to contribute to the sinking fund.

Of the sinking fund reserve for the rural lines totalling $195.11, an amount of $190.56 was charged against the municipality of Brockville, and $4.55 against Chesterville.

In connection with the sinking fund provision it is interesting to note that of the total amount of $15,197 charged up to October 31st, 1921, the sum of $4,479.54 has been charged against companies receiving power. Consideration should be given to the question of whether such consumers are or are not building up an equity in the System, and whether it is proper for them to do so if the Hydro-Electric Power Commission is supplying power to them on any other basis than cost on the partnership system.

Reserve for Contingencies.

Up to the end of 1921 the total reserve for contingencies was about $5,372 made up of annual charge of 25 cents per horse-power on the average power billed to the municipalities and to private companies, excepting in 1920 when the rate was $1.50 per horse-power, together with a profit of sales on miscellaneous equipment and interest at 4 per cent. on the balance of the account.

The total amount built up for the account to October 31st, 1921, was originally $7,675, from which has been deducted the loss on power sold to companies in 1919 and 1920, adjustments of losses due to reduction in renewal rates in 1921, and expenses covering contingencies met with, the whole amounting to $4,303, leaving a net balance of $3,372.

In view of occurrences such as the financial situation of the Cornwall Pulp & Paper Company and the large amount of capital invested it would appear that the reserve for contingencies is somewhat too small. Having in mind the heavy losses which might be occasioned through catastrophe as well as possible

bad debts such as have already occurred, it is felt that the total amount at the credit of this fund should be augmented by increasing the allowances for contingencies, and when a reserve of say $12,000 or $15,000 will have been built up the rates can be readjusted to suit the conditions found after several further years of experience.

Discussion of Deficits and Surpluses.

The records show that the System as a whole has been billed with the cost of power in accordance with the book-keeping methods of the Hydro-Electric Power Commission since 1918, and that there are now no deficits or surpluses for the System as a whole. This does not take into account the local distribution in the various municipalities, which is done by the municipality itself or by a separate commission in such municipality, and where the profits or losses are not included in the accounts of the Hydro-Electric Power Commission for the St. Lawrence System.

Revenues and Costs per Horse-power per Annum.

In order to reduce the total costs of operation to a basis where these would be comparable with other systems a set of diagrams has been prepared to show the costs of horse-power per annum for different bases of horse-power, and have also been analyzed to show the total annual costs subdivided into fractional amounts chargeable against each kind of expense, based on the

horse-power purchased per annum.

The table on page 47 and the sheet of curves on page 49 show the details of the total cost per horse-power per annum on different bases. The figures from which the curves were plotted are the figures given of total costs, on page 35, divided by the figures for the various classes of horse-power already given on page 26. It will be noted from the tables on pages 31 and 35 that the total revenues per annum do not quite balance with the total costs for the reasons already discussed, as the adjustment figures later made in the accounting are not included herein, but the figures agree so closely that no curves of revenues per horse-power per annum have been plotted.

The table on page 47 and the sheet of curves on page 50 showing the subdivided costs per annum per horse-power purchased, indicate the subdivision of the total annual costs as between power purchased, operating, maintenance, overhead and general expense, interest, renewals, sinking fund and contingencies, divided by the total amount of horse-power purchased each year for the St. Lawrence System.

The table on page 47 has been prepared to show the subdivided costs per average horse-power taken by the System, in other words they represent the cost per horse-power on a basis of 100 per cent. load factor. As the figures are available for the years 1920 and 1921 only, no curves have been plotted for them.

If further analyses are desired, similar tables and curves might be prepared on the basis of the horse-power billed to the consumers and for peak horse-power, but these have not been plotted for the present report. The

tables are as follows:

Table of Total Costs per Horse-power per Annum

	1918	1919	1920	1921
H.P. Purchased	$51.28	$51.71	$46.48	$42.95
H.P. Taken by System, Average	-	-	80.41	80.45
H.P. Billed to Consumers	38.70	44.16	49.22	50.40
H.P. Average of Twelve Monthly Peaks	-	54.04	48.55	42.63
H.P. Maximum Yearly Peak	-	34.45	42.67	27.70

Table of Subdivided Costs per Horse-power Purchased

COPY

	1918	1919	1920	1921
Power Purchased	$12.15	$14.23	$14.98	$15.90
Operating Costs	0.76	3.38	2.25	0.99
Maintenance	9.30	2.85	1.51	2.27
Overhead and General Expense	3.51	4.36	3.77	4.12
Interest	12.62	13.81	10.92	10.25
Renewals	12.62	12.71	9.57	6.76
Sinking Fund	-	-	2.06	3.35
Contingencies	0.33	0.37	1.42	0.21
Totals	$51.29	$51.71	$46.48	$42.95

Table of Subdivided Costs per Average Horse-power

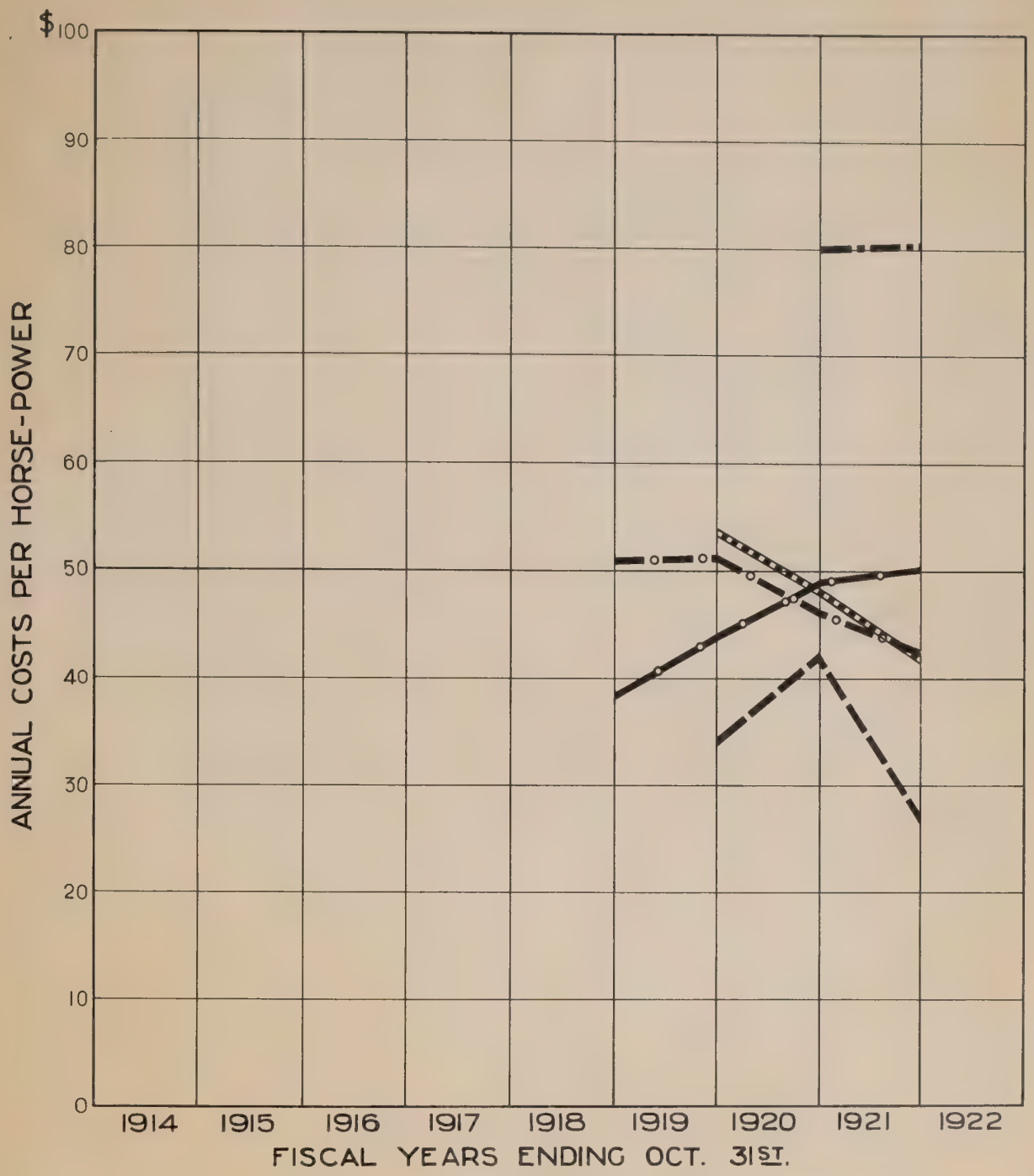
	1920	1921	1922
Power Purchased	$25.94	$28.10	-
Operating Costs	3.88	1.84	-
Maintenance	2.63	4.23	-
Overhead and General Expense	6.52	7.72	-
Interest	18.86	19.21	-
Renewals	16.56	12.57	-
Sinking Fund	3.57	6.27	-
Contingencies	2.45	0.41	-
Totals	$80.41	$80.45	-

Kilowatt-hour Data and Annual Revenues and Costs per Kilowatt-hour.

The engineers of the Hydro-Electric Power Commission of Ontario state that prior to 1920 there is no reliable record of the number of kilowatt-hours supplied to the St. Lawrence System, and that since that time they are only able to supply the total kilowatt-hours supplied at the main receiving point. The number of kilowatt-hours was 8,478,500 for the fiscal year ending October 31st, 1920, and 10,795,000 in 1921, and 14,652,500 in 1922.

The tables on page 51 and the sheet of curves included as page 52 show the kilowatt-hours supplied for different purposes in five of the municipalities supplied by the St. Lawrence System for the year 1921, and also show the kilowatt-hours consumed for various classes of service averaged for the whole of the St. Lawrence System from 1918 to 1922 inclusive. The figures indicate the difficulty of comparing one place with another, as will be seen by the wide variation in the details given for various places.

Included in the sheet of curves on page 52 is also a curve showing the growth in the number of consumers, and a curve showing the total cost of energy in cents per kilowatt-hour. As revenues and costs are nearly identical no attempt has been made to plot the revenues per kilowatt-hour. The costs per kilowatt-hour for the years 1920, 1921 and 1922 only are shown. These were about 1.23 cents per kilowatt-hour in 1920 and 1921, and slightly less in 1922.



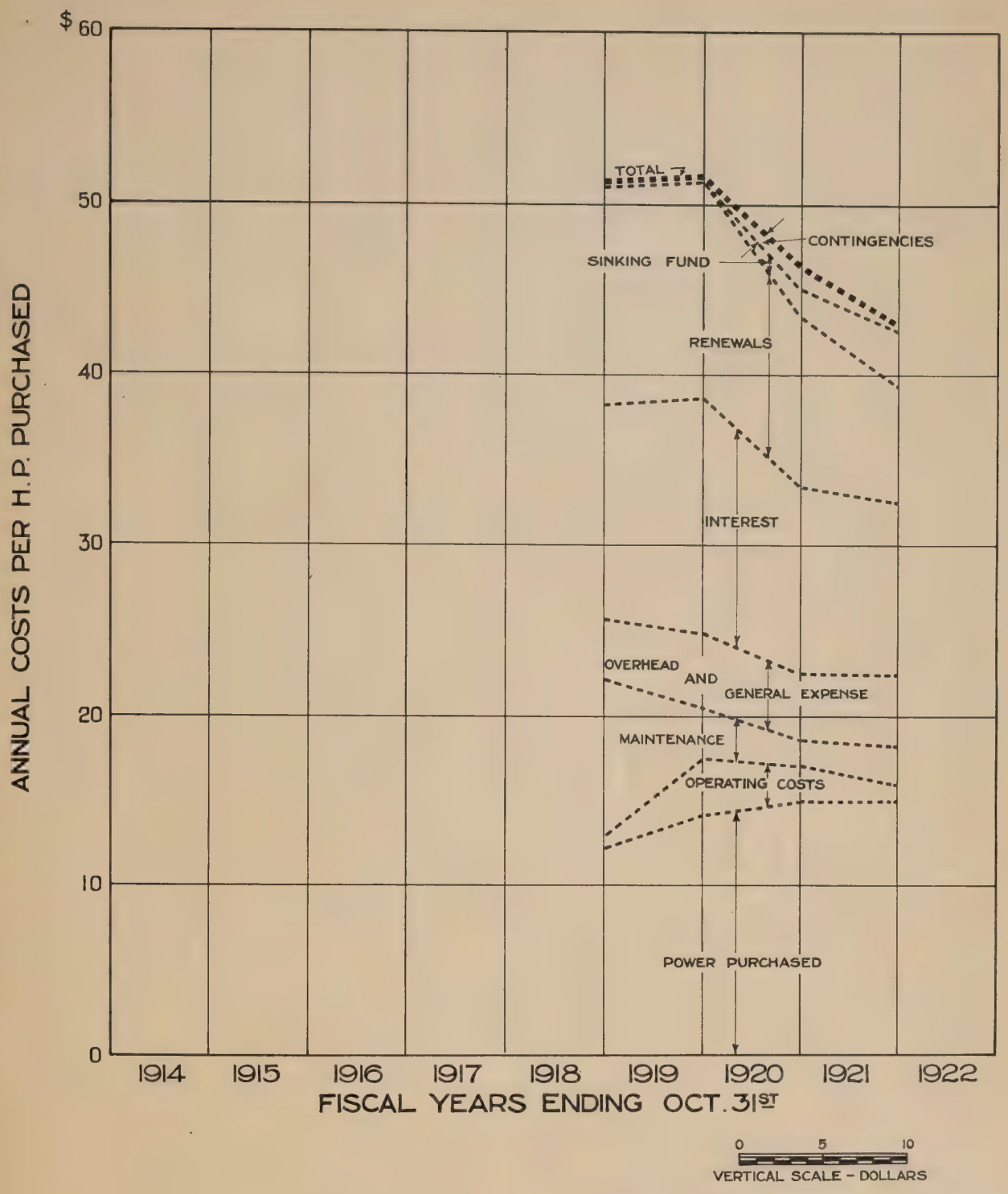
0 5 10
VERTICAL SCALE - DOLLARS

COSTS PER H.P.-AVERAGE TAKEN BY SYSTEM
" " " " PURCHASED
" " " " BILLED
" " " "-AVERAGE OF 12 MONTHLY PEAKS
" " " "-MAXIMUM YEARLY PEAK

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM
COSTS PER H.P. PER ANNUM, VARIOUS H.P. BASES

Toronto, Feb. 15th, 1923. Made by H.P.O. Checked by L.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM

SUBDIVIDED COSTS PER ANNUM PER H.P. PURCHASED

Toronto Feb. 15th, 1923. Made by [illegible], Checked by [illegible]

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Table of Power Consumption by Municipalities

Place	K.W.H. per Domestic Consumer	Calendar Year 1921 K.W.H. per Commercial Light Consumer	Horse-power per Power Consumer
Brockville	248	1,140	18
Prescott	262	576	15
Chesterville	318	1,015*	51
Williamsburg	141	544*	9
Winchester	382	609	12.5

* 1920 figures

Table of Kilowatt-hour Consumption - Various Classes

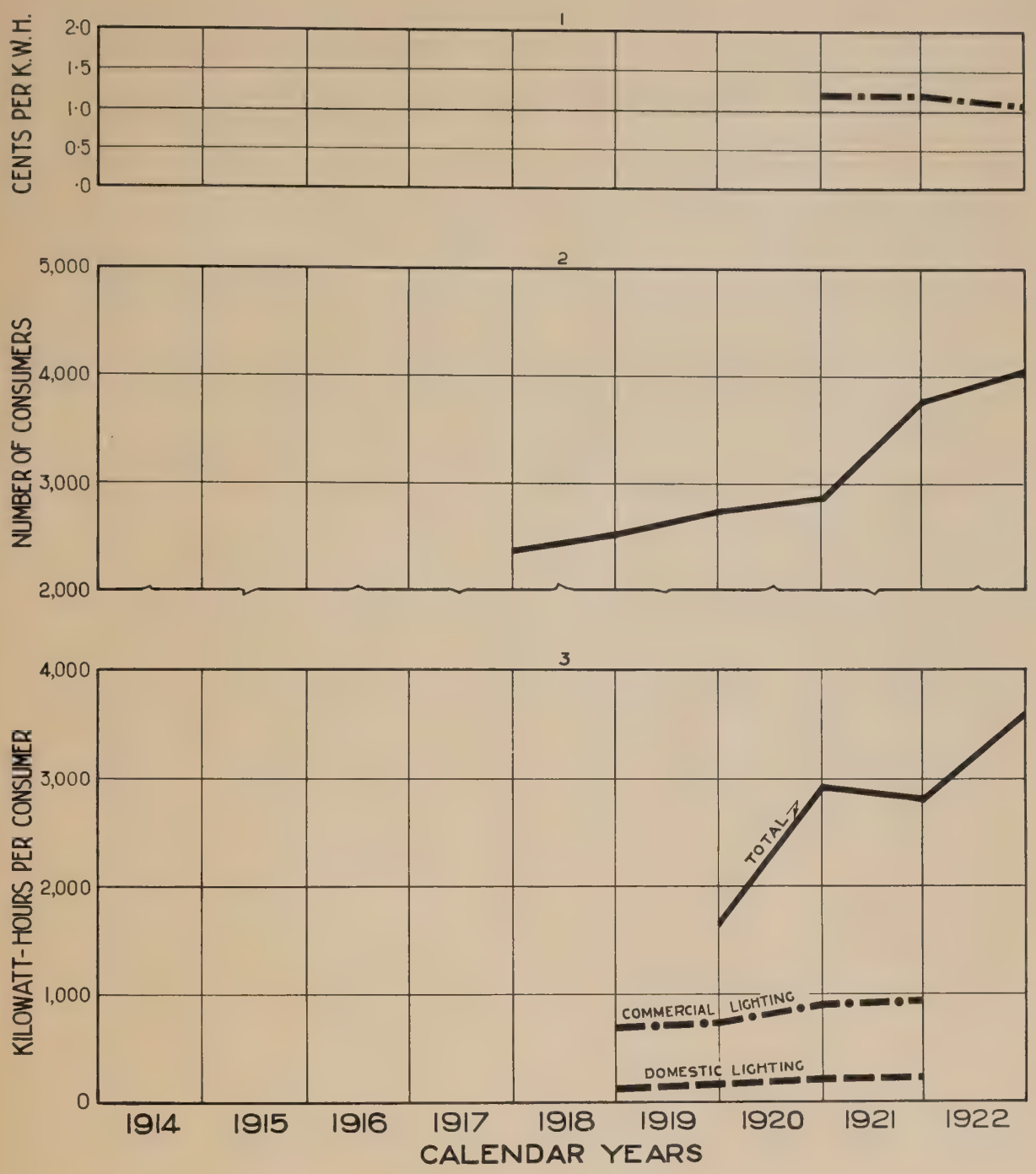
	Calendar Years 1918	1919	1920	1921	1922
K.W.H. per Domestic Light Consumer	158	200	253	265	-
K.W.H. per Commercial Light Consumer	725	770	930	952	-
Total K.W.H. per Consumer	-	1,700	2,950	2,840	3,600

(using total kilowatt-hours supplied by fiscal years)

Summary.

A summary of a number of the more salient points which have been studied and discussed in the foregoing report may be of advantage in continuing the consideration of the economics of the St. Lawrence System. They are as follows:

(1) The capital costs of the St. Lawrence System contain nothing for generating plants, nothing for intangible values and nothing for individual properties. The capital costs per horse-power based on the plant load on the system are comparatively high when it is considered that only transforming and distributing stations and transmission lines are included in the capital costs and that the plant load is comparatively small while the system extends over a large area. As the load increases the capital costs per horse-power will decrease, and by the time the present system is fully loaded the capital costs per horse-power should be very much smaller



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VERTICAL SCALE - DIAGRAMS 2 & 3

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

ST. LAWRENCE SYSTEM

KILOWATT-HOUR DATA

Toronto, Feb. 15th., 1923. Made by [illegible] Checked by [illegible]

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CONSULTING ENGINEERS

than at present.

(2) In considering extensions for the St. Lawrence System, consideration should be given to the question of utilizing local sources of power and direct routes of transmission lines from these sources where such are available. The proposals of the Beach Company are an example of the possibilities in this connection.

(3) In the construction of the St. Lawrence System some disappointments have been evident owing to the difference between actual amounts of power taken and the actual cost of power billed as compared with the estimated prices given before construction. Some method of closer co-operation between the Hydro-Electric Power Commission and the Municipalities concerned should be devised to avoid misunderstandings in the future.

(4) Capital costs projected for 1922 and 1923 amounting to about $400,000 would make the total investment in the St. Lawrence System approximately $1,250,000 at October 1923. The subdivision of this amount for extensions is about $100,000 in connection with the Cornwall station, $200,000 for transmission lines, and about $100,000 for rural lines. The necessity for these expenses should be determined, having in mind the possibility of paralleling of lines by competitive companies, remembering that the objective is to serve the population of the district to best advantage.

(5) To facilitate future economic studies and to assist in operating efficiency it would be well to keep accurate records of kilowatt-hours used at each principal consuming point on the System.

(6) The market for power is divided in the district as between the Hydro-Electric Power Commission and other interests. The total population served at the present time is only about one-quarter that of the district. The percentage of consumers to population now served is about 20 per cent., which compares fairly well with similar ratios in other districts. The use of electricity per ordinary consumer is apparently less in this district than in many others. The recent growth in load indicates that the demands are growing and it is likely that a considerable increase will take place in the power demand of the district. The ultimate demand of the whole System can probably be alwayswell covered by transmitted power either from the St. Lawrence River or the Ottawa River or the Gatineau River.

Some method of satisfactorily utilizing the available individual power plants in the district might be considered where these are not required for private use or by municipalities not now served by the Hydro-Electric Power Commission.

(7) The reserve for renewals should be carefully considered in its relation to the recently revised estimated useful life for various

portions of the property, and also adjusted to allow for the actual cost of money year by year.

(8) The question of sinking fund should be considered in relation to the sums charged against private companies which would be thus theoretically building up an equity in the St. Lawrence System. Where such companies are not partners, it is likely that no such sinking fund charge should be made as such.

(9) The reserve for contingencies might with advantage be increased to provide for catastrophe, bad debts, and so forth, on a somewhat more generous scale than has been done in the past.

(10) The operating records indicate that the System as a whole is being operated so as to supply power at cost, there being practically no difference between total earnings and total costs as shown by the auditor's reports.

(11) Consideration might be given to the question of adjusting rates in some of the smaller municipalities, especially under competitive conditions, with a view to equalising the costs as between rural and municipal consumers where these are of comparable amount and service, for example at Chesterville, Winchester and similar places.

Walter J. Francis

Consulting Engineer.